Spitzer/MIPS Infrared Imaging of the Extremely Extended Circumstellar Dust Shell of HD 161796

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I. Introduction

As stars with $0.8 < M_{MS} < 8$ evolve, they follow a path on the H-R diagram up the asymptotic giant branch (AGB) where they begin to lose much of their mass. This mass loss leads to the formation of a circumstellar shell of gas and dust. At the end of the AGB phase, mass loss stops and the circumstellar shell begins to drift away from the star. As the circumstellar shell disperses into the interstellar medium (ISM) these stars move to the blue side of the H-R diagram, evolving towards the planetary nebula phase. This is shown schematically in Fig. 1.

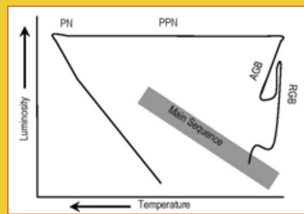
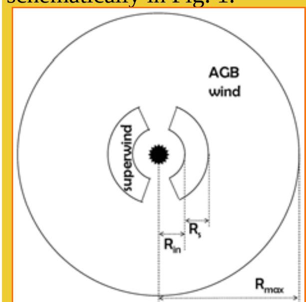


***Figure 1**: Schematic of intermediate mass stellar evolution on H-R diagram*



Assuming outflow velocities remain constant during the AGB phase, circumstellar shells of AGB and post-AGB stars contain the fossil record of their mass loss, and therefore have the potential to verify many aspects of stellar evolution. A schematic view of the post-AGB dust shell is shown in Fig. 2.

***Figure 2**: Schematic of structure of post AGB dustshell. R_{in} is the inner dust radius; R_s is the radius to which the superwind/axisymmetric mass loss extends; R_{max} is the edge of the dust shell*

IRAS and ISO data indicate that huge dust shells exist around many such objects, extending several parsecs from the central star. Furthermore, some of these large dust shells show evidence for mass-loss variations that correlate with evolutionary changes in the star itself.

Previous observations lacked the sensitivity and spatial resolution to investigate the full extent and detailed structure of these large dust shells.

Using Spitzer/MIPS's unique sensitivity and mapping capabilities, we are mapping the very extended dust shells around four (post-)AGB stars. From this study we will be able to (a) constrain the mass of the progenitor star; (b) test theories of stellar evolution and mass-loss mechanisms; (c) determine the effect of dust chemistry on mass loss (and therefore on stellar evolution); and (d) determine when the aspherical structures so prevalent in planetary nebulae actually occur and thus constrain the cause.

Here we present preliminary images of post-AGB stars HD 161796 at 160μm.

II. Observations

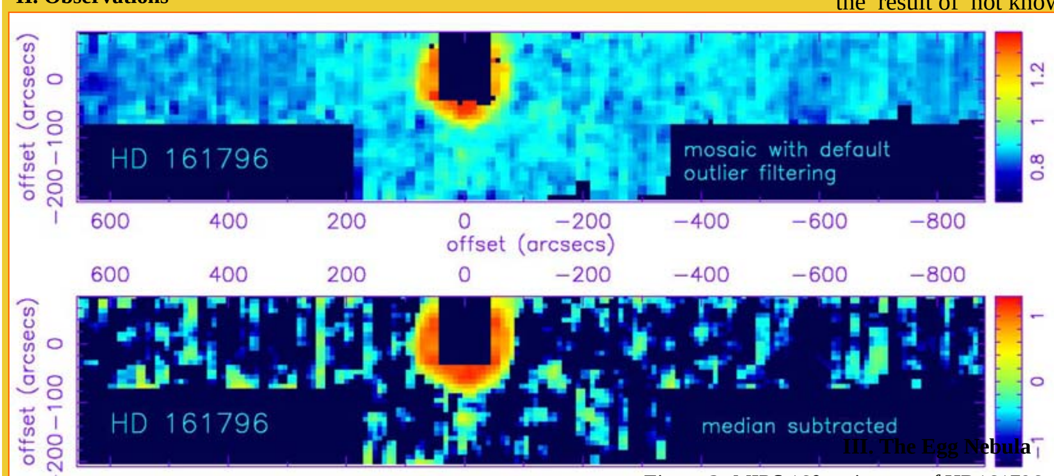


Figure 3: MIPS 160μm images of HD161796.

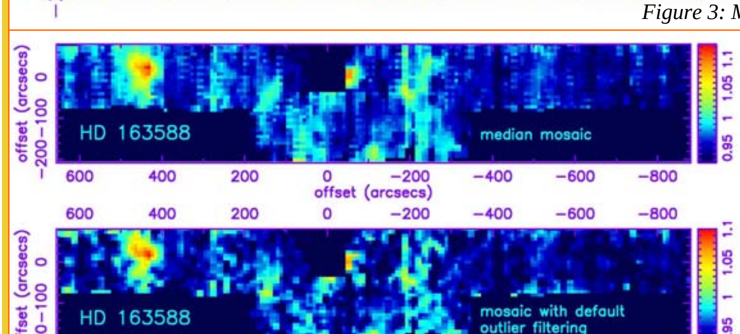


Figure 4: MIPS 160μm images of point source HD163588.

Figure 3 shows the distribution of 160μm emission around HD 161796, while Fig. 4 shows that for our point source, HD 163588. Comparison shows that HD 161796 appears to be extended to ~100", with lower level emission possibly extending as far as 300" on the left; and 500" on the right

***Figure 5**: Comparison of emission profiles for HD 161796 and HD 163588 (a point source)*

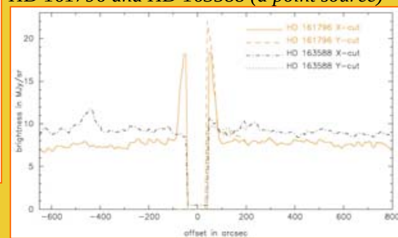


***Figure 6**: Comparison of MIPS and ISO emission profiles for HD 161796.*

Comparison of the emission profiles for HD 161796 and HD 163588 show that HD 161796 is extended to a radius of ~100". The marginal extension out to ~300-500" is also seen (just).

Object	*Observation*	*Orientation (W of N)*
HD 161796	MIPS 160μm	155º
HD 161796	ISO 160μm	152º
HD 161796	ISO 90μm	152º
Egg Nebula	MIPS 160μm	168º
Egg Nebula	ISO 120μm	172º
Egg Nebula	ISO 180μm	172º

III. Light leakage

MIPS is known to suffer from a Near-IR "light leak". When the 1.6μm emission is much brighter than the 160μm emission there is a displacement and distortion of the PSF (shown in Fig. 6). The lop-sided low-level extended emission seen in Fig. 3 is not due to this effect.

Figure 7: MIPS 160μm NIR light-leakage

Only the J-band flux causes this problem, and only for objects brighter than m(J) = 5.5. For HD 161796, m(J) = 6.22.

IV. Application of MIPS data

Previous models of the dust around HD 161796 have produced conflicting results (e.g. Gledhill & Yates 2003 , MNRAS, 343, 880; Meixner et al., 2002, ApJ, 571,936; Hoogzaad et al. 2002, A&A, 389, 547). However, this is partly the result of not knowing the full spatial extent of the dust shell. The MIPS images will allow us to define the edge of the dust shell, and aid radiative transfer modeling.

Gledhill & Yates (2003, MNRAS, 343, 880.) showed that the axisymmetric region of HD 161796's dust shell, close to the central star, appears to be twisted. This may also account for the apparent lopsided-ness of the dust shell seen in the 160μm image. Future work will investigate this possibility.

IV. Egg Nebula

Another post-AGB object which has been mapped at 160μm with MIPS is the Egg Nebula. Fig. 6 shows a comparison between the MIPS 160μm emission profile and those observed by ISO at 120 and 180μm. The apparent bump in the emission profile at an offset of ~160" matches these previous observations. However, it is possible that this feature is related to the PSF of the observations and further study is now required to determine whether the emission bump at ~160" is real or an observational artifact.

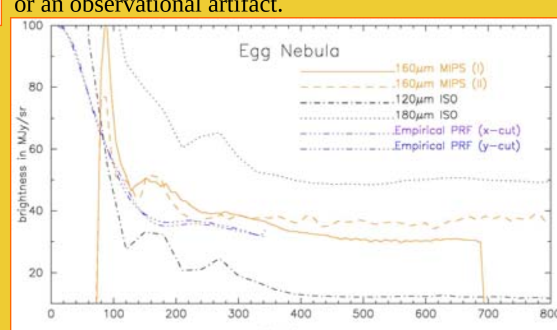


Figure 8: Radial emission profiles for the Egg Nebula